International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249-6890; ISSN (E): 2249-8001
Vol. 9, Issue 3, Jun 2019, 625-630

CFD ANALYSIS OF THE AERODYNAMIC CHARACTERISTICS OF SWEPT BACK WING BY CHANGING ITS TAPER RATIO

S. ELANGOVAN[1], M. SUNDARARAJ[2] & D. HASEN[3]

[1]Dean and Professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Chennai Tamil Nadu, India

[2]Head and Associate Professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India

[3]Assistant professor, Department of Aeronautical Engineering, Bharath Institute of Higher Education and Research, Chennai, Tamil Nadu, India

ABSTRACT

In this paper, efforts were made to predict the aerodynamic characteristics of swept back wing employed in F-18 aircraft by changing its taper ratio. NACA 4412 airfoil coordinates were chosen for designing the wing with a span of 22 cm. a set of wings was constructed by varying its taper ratio and the flow features over the wing were analyzed at various angles of attack (0, 5, 10, 15 degrees). Designing of wing was carried out using CATIA V5 software. Discretization and simulations of the models were done using ANSYS CFX software. The lift coefficient, drag coefficient and aerodynamic coefficient values were calculated using the simulation result and the values were plotted against angle of attack. From the computational analysis, the pressure variation, Mach number variation, velocity variation and turbulence contours were observed. The observed results of different wing configurations were compared among themselves to figure out the aerodynamically efficient configuration. The investigated concept of swept back wings with variable taper ratio seems to be an alternative for improving aircraft's aerodynamic efficiency.

KEYWORDS: Taper Ratio, Swept Back Wings, Aerodynamic Efficiency & Angle of Attack

Received: Mar 14, 2019; **Accepted**: Apr 04, 2019; **Published**: May 03, 2019; **Paper Id**.: IJMPERDJUN201968

Original Article

INTRODUCTION

The requirements for the military transport aircraft has been increased considerably now days. The design criteria of the military aircrafts include the size, weight and the high speed performance of the aircrafts. Now a day the role of military aircraft has been changed drastically. The most leading aircraft manufacturer, Boeing decided to use the technologies from aircrafts which are efficient at transonic speeds with the technologies which provide high landing and take-off performance. This newly made combined configuration resembles the transonic efficient aircrafts. The aircraft wing design methodology based on the selection of airfoil. The airfoil selected for high performance aircraft should be high lift to drag ratio and high aerodynamic stability. The development in the field of better aerodynamics brings new concept in the designing of wings. In this, Swept wings play a major role in exhibiting high aerodynamic performance. Different configurations of the swept wings have been evolved to meet best performances at high cruising speed. The lift generation mechanism of the swept wings is completely different when compared with other kind of wing configurations. The stalling angle for the swept wing is high when compared with normal wings. The swept wing with sharp leading edge shows better results and it is suitable for

supersonic flights because it produces low supersonic wave drag. In this paper, the swept wing was analyzed by changing the taper ratio of the wing. The taper ratio is changed by changing the tip chord value of the wing. The model was designed using CATIA V5 software. The discretization, pre and post processing was done by using ANSYS software packages. The changes in the flow parameters, flow patterns and the aerodynamic characteristics of different swept wing configurations were observed and recorded in this paper.

MODELING AND SIMULATION

A three dimensional Swept wing was designed using CATIA V5 software. NACA 4412 airfoil was chosen for this study. The span of the swept wing is 22cm. Swept back wing was considered for this analysis with sweep angle of 19.03 degree. Swept wing is having root chord value of 9.4 cm and tip chord value of 2.9 for taper ratio 0.3 and 3.9 for 0.4 taper ratio values.

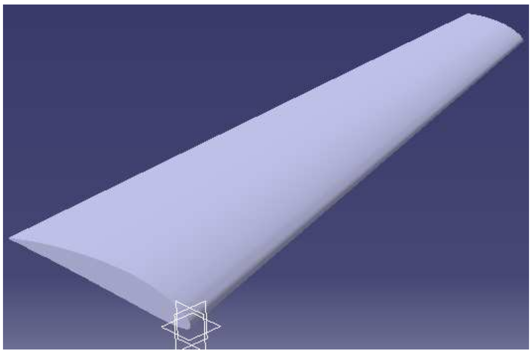


Figure 1: Swept Back Wing

The designed swept back wing model was imported into ICEMCFD for discretization. The hemispherical domain was created around the swept back wing. The domain needs to be meshed since it deals with the external aerodynamics. Triangular shaped elements were chosen for discretization and the mesh quality was good.

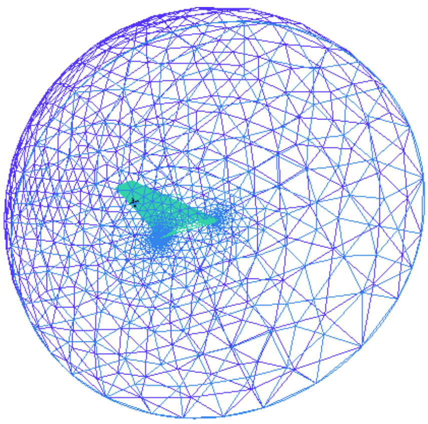


Figure 2: Discretized Model of Swept Wing

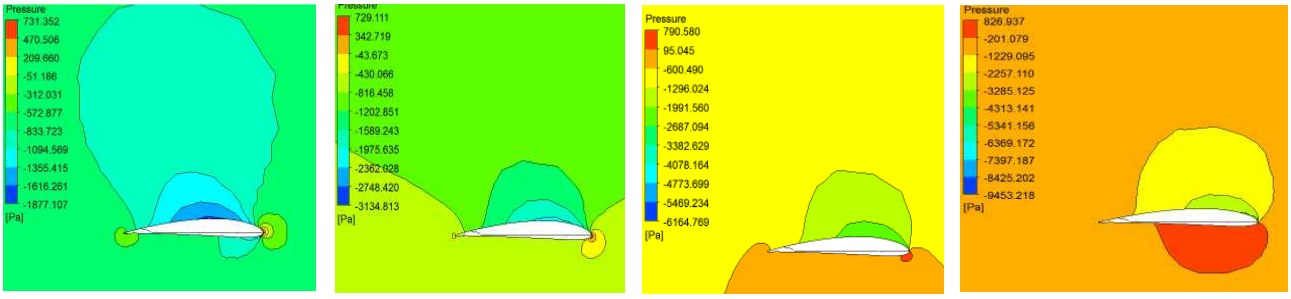
RESULTS AND DISCUSSIONS

NACA 4412 airfoil was chosen for this flow study. Velocity was given as the major boundary condition. Two different taper ratios were considered for this analysis and they are 0.3 and 0.4. Also the wing was subjected to the angle of attacks such as 0, 5, 10 and 15 degrees. The pre and post processing were done using ANSYS software packages. The pressure and velocity contours for different cases were published in this paper. The total analyses were carried out for the

velocity of 50m/s.

For Taper Ratio 0.3

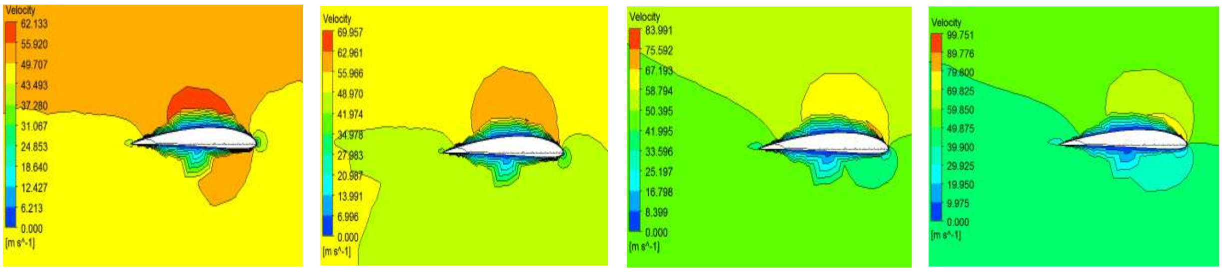
Pressure Contour



0 degree 5 degree 10 degree 15 degree

Figure 3: Pressure Contour of Swept Wing at Various AOA with Taper ratio 0.3

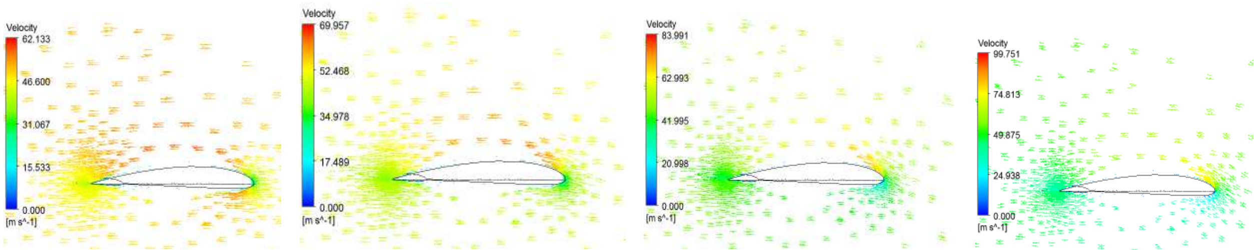
Velocity Contour



0 degree 5 degree 10 degree 15 degree

Figure 4: Velocity Contour of Swept Wing at Various AOA with Taper ratio 0.3

Velocity Vector Contour

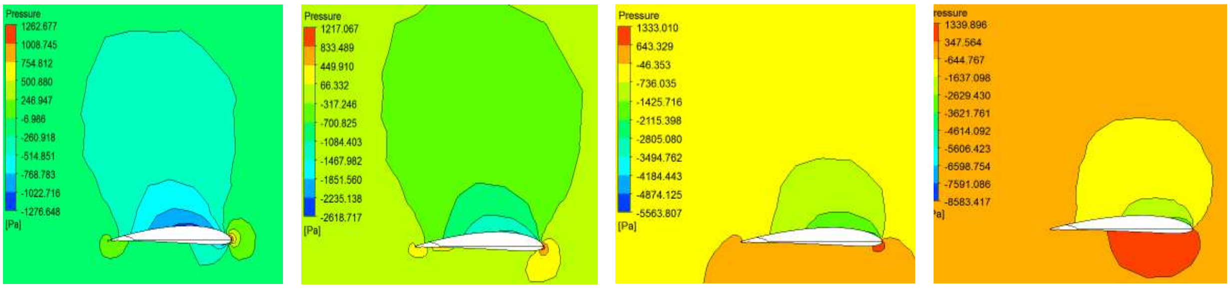


0 degree 5 degree 10 degree 15 degree

Figure 5: Velocity Vector Contour of Swept Wing at Various AOA with Taper Ratio 0.3

For Taper Ratio 0.4

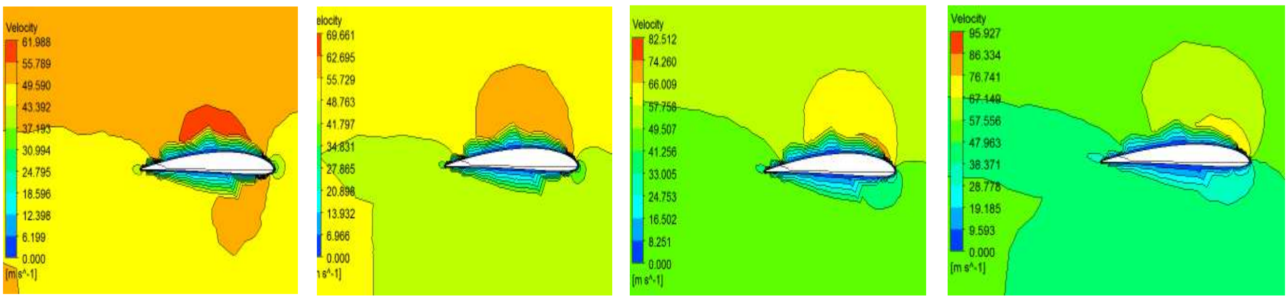
Pressure Contour



0 degree 5 degree 10 degree 15 degree

Figure 6: Pressure Contour of Swept Wing at Various AOA with Taper Ratio 0.4

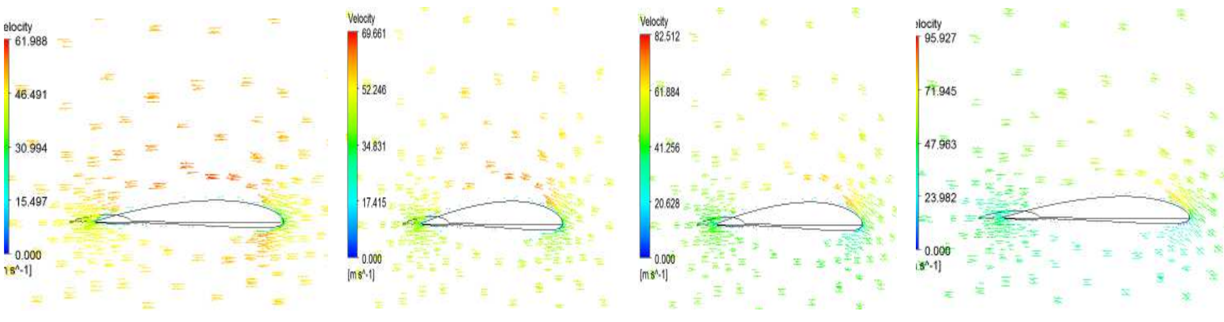
Velocity Contour



0 degree 5 degree 10 degree 15 degree

Figure 7: Pressure Contour of Swept Wing at Various AOA with Taper Ratio 0.4

Velocity Vector Contour



0 degree 5 degree 10 degree 15 degree

Figure 8: Pressure Contour of Swept Wing at Various AOA with Taper Ratio 0.4

CONCLUSIONS

Computational study was done by considering the changes in the taper ratio between the leading edge chord and trailing edge chord values of the swept wing. The wing was subjected to various angles of attacks to capture the aerodynamic characteristics of the wing. This project is an effort to visualize the changes in the nature of flows when it is subjected into such stated conditions. The obtained results were recorded in this paper. The pressure field changes associated with the taper ratio was clearly recorded will help us to ensure about the aerodynamic efficiency of the swept

wing.

REFERENCES

1. *Abbott I H, Von DoenhoffA E. Theory of wing sections, including a summary of airfoil data.1st ed. New York: Dover Publications; 1959.*
2. *Wentz W H Jr, Kohlman D L. Wind tunnel investigation of vortex breakdown on slender sharp edged wings. NASA Research Grant NGR-17-002-043, 1968.*
3. *Polhamus E C. A concept of the vortex lift of sharp edged delta wings based on a leading edge suction analogy. NASA TN D-3767, 1966.*
4. *Chu, J. and Luckring, J. M. 1996. Experimental surface pressure data obtained on 65°delta wing across Reynolds number and Mach number ranges. NASATM-4645,*
5. *Gursul, I. and Yang, H. 1995. Vortex breakdown over a pitching delta wing.J Fluids Struct. 9:571-583.*
6. *Huang, X. Z. and Verhaagen, N. G. 2008. Vortex flow behavior over slender delta wing configurations:experimental studies numerical and analytical solutions. Springer.*
7. *Robert, C. Nelson and Alain, Pelletier. 2003. The unsteady aerodynamics of slender wings and aircraft undergoing large amplitude maneuvers. Progress in Aerospace Sciences. 39:185–248.*
8. *Nikam, H., Mishra, P. R. E. M., & Bharambe, S. (2014). Design and Analysis of Brake Rotor with Parameter Optimization. International Journal of Automobile Engineering Research and Development (IJAuERD), 4(4), 21-30.*
9. *Guglieri, G. and Quagliotti, F. B. Experimental investigation of vortex dynamics on a 65° delta wing. Agard report RTO-TR-AVT-080, Chapter 10.*
10. *Lambourne, N. C. and Bryer, D. W. 1962. The bursting of leading edge vortices-some observations and discussion of the phenomenon, Aeronautical Research Council.R and M No. 3282.*
11. *Hummel, D. and Estorf, M. Unsymmetric vortex breakdown for symmetric free stream conditions. RTO-TR-AVT-080, Chapter 19.*
12. *Gurusul, I. and Yang, H. 1995. Vortex breakdown over a pitching delta wing.Journal of fluid and structures. 9:571-583.*
13. *Earnshaw, P. B. and Lawford, J. A. 1964. Low speed wind tunnel experiments on series of sharp-edged delta wings. Aeronautical Research Council. R & M No. 3424.*
14. *Verhaagen, N. G. 1999. Effect of sideslip on the flow over a 65 deg delta wing, EOARD SPC 97-4067.*
15. *Woodiga, S. A. and Liu, Tianshu. 2009. Skin friction fields on delta wings. Exp fluids. 47:897-911.*
16. *Reddy, P. R., & Saikiran, M. (2016). Aerodynamic Analysis of Return Channel Vanes in Centrifugal Compressors. International Journal of Mechanical Engineering (IJME), 5(1), 73-82.*
17. *Huang, Xing. Comprehensive experimental studies on vortex dynamics over military wing configurations in IAR.AGARD Report.RTO-TR-AVT-080, Chapter-5.*